

NOAA National Centers for Environmental Information Topo-Bathymetric Digital Elevation Modeling: Lesser Antilles

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Introduction

This report briefly describes the creation of an integrated bathymetric-topographic digital elevation model (DEM) developed for an area in the Lesser Antilles by the NOAA National Centers for Environmental Information (NCEI; Fig. 1). The DEM covers an area of approximately 503,000 km², and includes the Leeward Islands from Anguilla to Marie-Galante (Guadeloupe), the Windward Islands from Dominica to Grenada, and Barbados. This work was funded by the National Weather Service under the auspices of the COASTAL Act Program to improve NOAA's storm surge modeling capabilities.

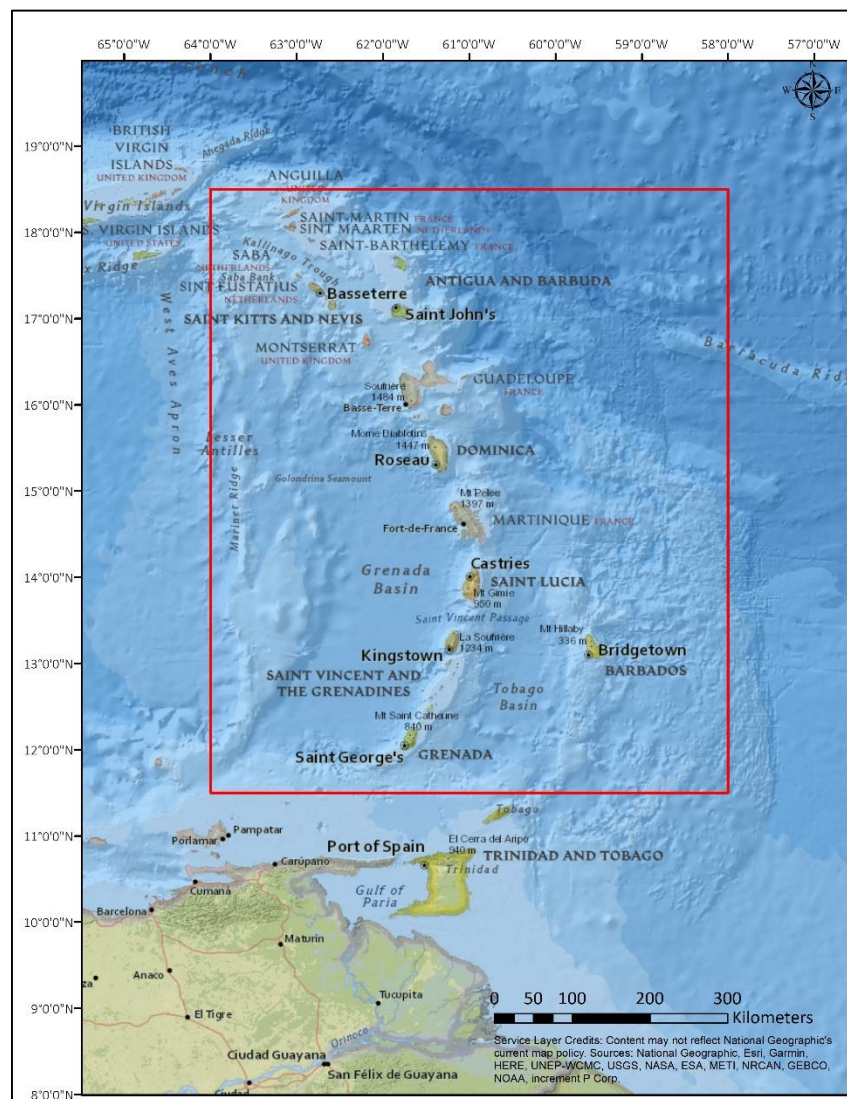


Figure 1. Spatial Extent of the 2018 NOAA NCEI Lesser Antilles Digital Elevation Model.

The DEM was created at a spatial resolution of 3 arc-seconds (~90 m). The DEM is horizontally referenced to the World Geodetic System of 1984 (WGS84). The vertical datum of the data is instantaneous water level- no corrections or adjustments were made to the elevation source data; at the resolution of the DEM this is assumed to approximate mean sea level.

Elevation Sources and Data Processing

Original source topographic and bathymetric data were obtained from a variety of U.S. and international organizations. Source data were obtained in a variety of different formats and referenced to disparate horizontal and vertical datums (Table 1).

Table 1. Source datasets used in the creation of the NOAA NCEI Lesser Antilles DEM

| Source Dataset | Data Type | Acquisition/Creation Date | Spatial Resolution | Horizontal Datum/Projection | Vertical Datum |
|---|-------------------------------------|---------------------------|----------------------------|-----------------------------|--|
| French Naval Hydrographic & Oceanographic Service (SHOM) Lidar | Gridded topographic DEM | 2010-2011 | 5 meters | WGS84/UTM Zone 20 | Various island specific orthometric datums |
| NASA Shuttle Radar Topography Mission (SRTM) version 2.1 | Gridded topographic DEM | 1994 | 1 arc-second (~30 meters) | WGS84 | EGM96 (Earth Gravitational Model of 1996) |
| French Naval Hydrographic & Oceanographic Service (SHOM) Digital Bathymetry Model | Gridded bathymetric DEM | 2015 | 100 m | WGS84/UTM Zone 20 | Lowest Astronomical Tide |
| NOAA NCEI Multibeam Database (see Appendix I) | Multibeam bathymetry soundings | 1985-2017 | Variable | WGS84 | Instantaneous Water Level (uncorrected) |
| NOAA NCEI Digital Elevation Model - Grenada | Gridded topographic-bathymetric DEM | 2017 | 1 arc-second (~30 meters) | WGS84 | Instantaneous Water Level (uncorrected) |
| Global Multi-Resolution Topography (GMRT) Synthesis v. 3.5 | Gridded topographic-bathymetric DEM | 2018 | 3 arc-seconds (~90 meters) | WGS84 | Instantaneous Water Level (uncorrected) |

All source data used in the creation of the DEM were converted to a common horizontal of WGS84 using various Geospatial Data Abstract Libraries (GDAL) utilities, which rely on spatial reference information maintained by the European Petroleum Survey Group (EPSG). All data were converted to a common data format (ASCII xyz) in preparation for gridding. For datasets obtained in raster format, a bilinear resampling algorithm was applied to the original source file in order to match the target spatial resolution of 3 arc-seconds, then converted to ASCII xyz

using GDAL. Multibeam bathymetry data were converted from sensor-specific binary data formats to ASCII xyz using MB-System's 'mblist' utility. The data was reviewed and evaluated for internal and external consistency with adjacent data. Anomalies were identified through visual inspection and removed with manual (area-based editing in a desktop GIS) and automated filtering.

MB-System's 'mbgrid' utility was used for gridding and interpolation. A tensioned thin-plate spline algorithm was used to interpolate depth values in pixels within the DEM extent that were unconstrained by elevation measurements. Constrained pixels were assigned a final elevation value based on the weighted average of the input source elevation measurements. The highest-resolution data sources (e.g. multibeam bathymetry and lidar) were preferentially weighted relative to global/lower-resolution datasets. A 2-D Gaussian convolution filter was applied to the bathymetric portion (i.e. elevations less than 0 meters) of the DEM generated during the gridding/interpolation process to smooth any persistent data anomalies and minimize vertical offsets between disparate data sources. The resultant smoothed bathymetry was then merged with the unfiltered gridded topography data to create the final DEM product.

No quantitative analysis was performed to assess the accuracy of the DEMs, although this continues to be an area of active research at NCEI (see Amante, 2018; Amante and Eakins, 2016).

For more information, contact dem.info@noaa.gov

References:

Amante, C.J., 2018. Estimating Coastal Digital Elevation Model Uncertainty. *Journal of Coastal Research*, In-Press.

Amante, C.J. and Eakins, B.W., 2016. Accuracy of interpolated bathymetry in digital elevation models. *In: Brock, J.C., Gesch, D.B., Parrish, C.E., Rogers, J.N., and Wright, C.W. (eds.), Advances in Topobathymetric Mapping, Models and Applications. Journal of Coastal Research*, Special Issue, No. 76, pp.122-133.

Appendix I – Multibeam sonar surveys used in the creation of the Lesser Antilles DEM

| Survey ID | Year | Ship |
|-----------|------|------------------|
| AT04L04 | 2001 | Atlantis |
| AT07L32 | 2003 | Atlantis |
| AT20 | 2012 | Atlantis |
| AT21-02 | 2012 | Atlantis |
| AT21-04 | 2012 | Atlantis |
| EW0308 | 2003 | Maurice Ewing |
| EW0309 | 2003 | Maurice Ewing |
| EW0404 | 2004 | Maurice Ewing |
| EW9206 | 1992 | Maurice Ewing |
| EW9207 | 1992 | Maurice Ewing |
| EW9304 | 1993 | Maurice Ewing |
| EW9403 | 1994 | Maurice Ewing |
| EW9404 | 1994 | Maurice Ewing |
| EW9802 | 1998 | Maurice Ewing |
| EW9803 | 1998 | Maurice Ewing |
| EW9901 | 1999 | Maurice Ewing |
| EW9902 | 1999 | Maurice Ewing |
| EX1502L1 | 2015 | Okeanos Explorer |
| FA170008 | 2017 | Fugro Americas |
| FA170009 | 2017 | Fugro Americas |
| HLY05TE | 2005 | Healy |
| HLY05TH | 2005 | Healy |
| KN151L4 | 1997 | Knorr |
| KN161L04 | 2000 | Knorr |
| KN161L07 | 2000 | Knorr |
| KN166L07 | 2002 | Knorr |
| KN166L08 | 2002 | Knorr |
| KN173L02 | 2003 | Knorr |
| KN176L03 | 2004 | Knorr |
| KN189-01 | 2007 | Knorr |
| KN189-02 | 2007 | Knorr |
| KN189-03 | 2007 | Knorr |
| KN197-08 | 2010 | Knorr |
| KN200-06 | 2011 | Knorr |
| MV1109 | 2011 | Melville |
| MV1110 | 2011 | Melville |
| MV1111 | 2011 | Melville |
| RB0302 | 2003 | Ronald H. Brown |
| RB0303 | 2003 | Ronald H. Brown |

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|--------|------|------------------|
| RB0305 | 2003 | Ronald H. Brown |
| RB0601 | 2006 | Ronald H. Brown |
| RB0604 | 2006 | Ronald H. Brown |
| RB1009 | 2010 | Ronald H. Brown |
| RC2603 | 1985 | Robert D. Conrad |
| RC2605 | 1985 | Robert D. Conrad |